Initial Project Description Report for Application of Fuel Cell Technology

Proton Exchange Membrane (PEM) Fuel Cell Demonstration of Domestically Produced Residential PEM Fuel Cells in Military Facilities

FAA Radio Transmit Receive Site
McChord Air Force Base, WA

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Introduction

Background

The Construction Engineering Research Laboratory (CERL) is a division of the U.S Army Corp of Engineers' Engineer Research and Development Center. CERL's mission is to assist the military in addressing existing needs, directing research, and developing products utilizing experimental technologies. The Residential Fuel Cell Program is intended to advance the development of PEM fuel cells and promote their penetration into the marketplace by providing long-term test data to Department of Defense personnel as well as fuel cell manufacturers.

The system designed for this installation utilizes six Avista Labs Independence 500 modular Proton Exchange Membrane (PEM) fuel cells. The Independence 500 fuel cell is a 500 watt battery-charging system. The six Independence 500 systems are connected in parallel to provide 3 kW of power. The fuel cells are housed in an outdoor enclosure with an integrated hydrogen storage and distribution system.

System Test

Figure 1 below depicts the system functional block diagram. An outdoor enclosure will house the six Independence 500 fuel cells along with an internal battery bank, and rectifier. The system is designed to simulate a typical DC powered system with battery backup. AC power will be connected to the enclosure to power the rectifier, which will charge the internal battery bank and power the DC controls and data logging computer. AC power will also be utilized to power temperature controlled heaters to maintain the temperature inside the enclosure above 40°F. During the system test, a Programmable Logic Controller (PLC 1) located in the outdoor enclosure will simulate a AC power outage by disconnecting AC from the rectifier and the heaters. At the same time the power outage is simulated, the fuel cell automatic start sequence is initiated. The system test will be broken down into two phases.

Phase 1 – Load bank Testing

The first phase will involve simulating a 20-minute loss of AC grid power and automatic startup of the fuel call system. A 3kW resistive load bank will then be ramped in as a load in 1kW increments during the 20-minute test. The load ramp will be in 5-minute intervals with the first five minutes at 1 kW, the next five minutes at 2 kW and the final ten minutes at 3kW. The test will be conducted three times a day, 7 days a week for the first two months.

Phase 2 – Radio Transmit Receive (RTR) Site Power

The second phase will involve continuing the test performed in the Phase 1 six days a week and connecting to the Federal Aviation Administration (FAA) Radio Transmit Receive (RTR) site for 2 hours one day a week. The connection to the FAA RTR site will involve simulating an AC grid power outage at the RTR site, automatic startup of the fuel cell system and automatic connection of the fuel cell system to the RTR site DC buss. The simulated power outage test will last 2 hours. See Figure 1 below.

Functional Block Diagram

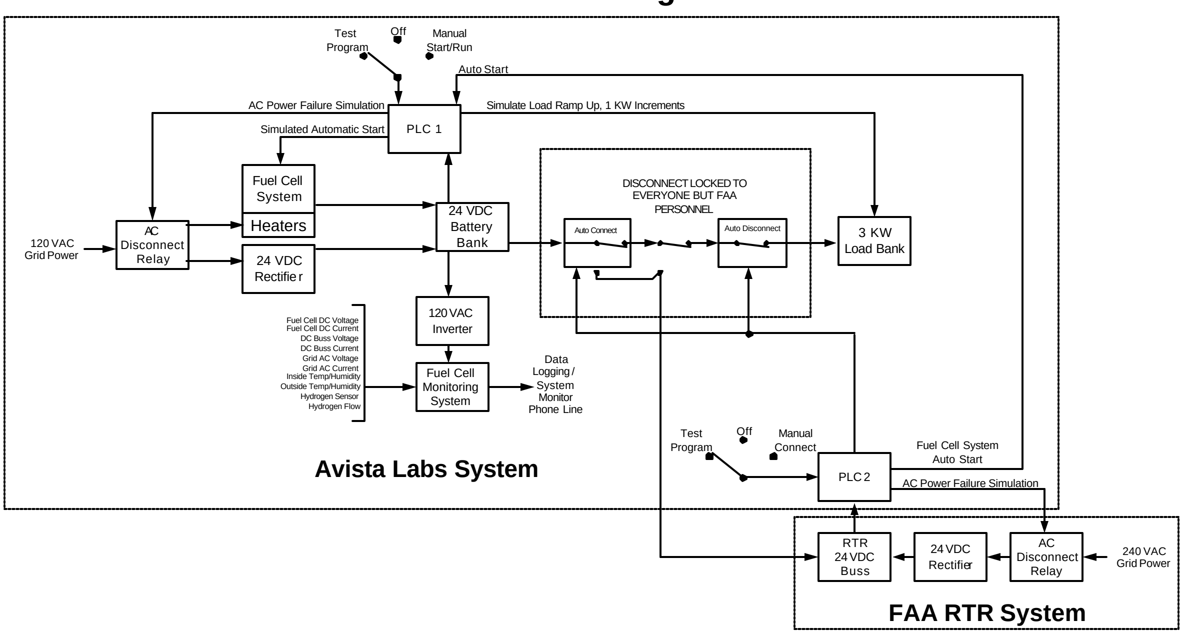

Figure 1

Objective

The objective of this project is to study the reliability, characteristics and cost of operating the Independence 500 PEM fuel cell system as a backup power source. Data to be collected will include total operating hours, kilowatt-hours of power produced, fuel consumption, maintenance logs, system availability, outages and operating temperature. Additionally, this project will serve to familiarize local approval agencies with PEM fuel cells, and further increase the efficiency of the approval process for installing PEM fuel cells. The test information will be utilized to obtain a better understanding of how fuel cells perform in backup power applications. This data will be used to improve current fuel cell products and will also be incorporated into future fuel cell product designs.

Points of Contact

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Site Information

The Federal Aviation Administration (FAA) Radio Transmit Receive (RTR) site is located in bldg. 1505 on McChord AFB, WA. Seattle/Tacoma International Airport and other air traffic control facilities in Western Washington use the radios at this site for air traffic control. A rectifier system connected to grid power provides 24 VDC power to the radios at the site. A battery bank is utilized for backup power during power outages. Figure 2 below is a digital photo of the East side of the RTR site.

Figure 2

Fuel Cell Outdoor Enclosure Layout

Figure 3 details the layout of the fuel cell outdoor enclosure. The equipment compartment cabinets will house the six Independence 500 fuel cell systems along with a rectifier, battery bank, circuit breakers and inverter.

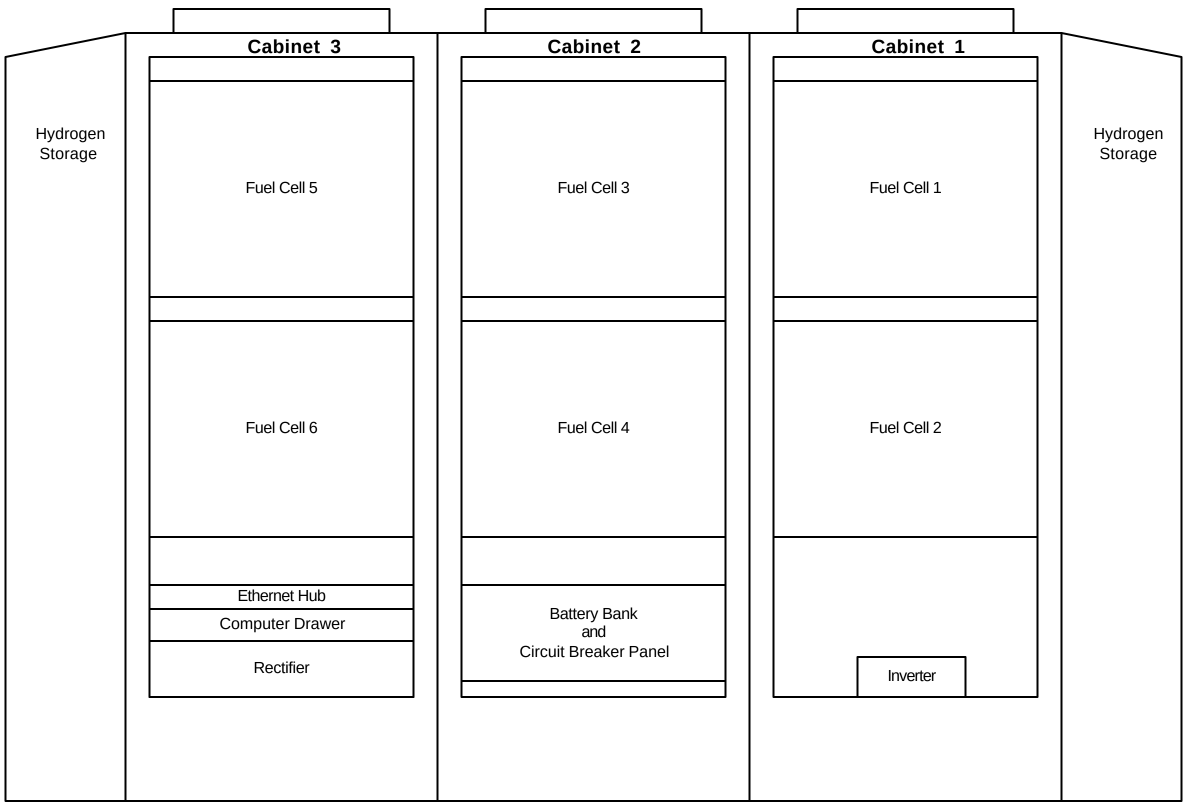

Figure 3

Fuel Cell Outdoor Enclosure Foot Print

As shown in Figure 4 below, the footprint of the outdoor enclosure is 96-inches by 36-inches. The enclosure will be placed on a composite concrete pad to facilitate ease of installation. The composite concrete pad will be delivered to the site and placed prior to installation of the outdoor enclosure.

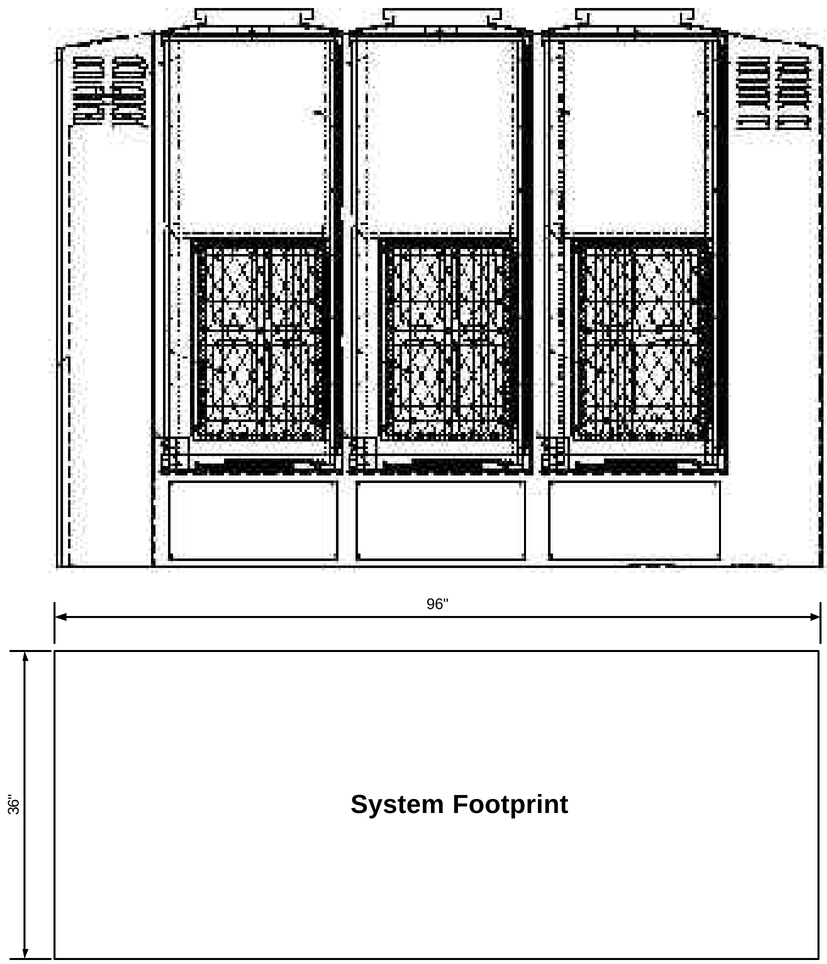

Figure 4

Site Layout

Figure 5 below details the proposed location for the fuel cell enclosure with integrated hydrogen fuel supply. The outdoor enclosure will be located at a distance of 40 feet from East side of the building. The load bank will be placed on the East side of the building on a concrete pad. Three conduits will be run from the building to the enclosure pad. The conduits will be used for AC power to the fuel cell enclosure, DC power from the fuel cell enclosure to the load bank and the building, control circuits wiring and telephone cables used for data logging and alert notification. A 2/0 AWG ground cable will be connected between the facility ground system and the fuel cell enclosure. After the conduits are installed gravel will placed and the site will be graded and compacted. The composite concrete pad will be installed for placement of the outdoor enclosure. Concrete filled bollards will be placed around the outdoor enclosure to prevent damage from vehicles. An AC disconnect, DC Disconnect and Telephone/Control cable junction box will be placed on a distribution back plane near the East side of Bldg. 1505, see Figure 6. Two junction boxes will be placed on a distribution back plane near the load bank pad for solid state relays and DC connection contactors, see Figure 7.

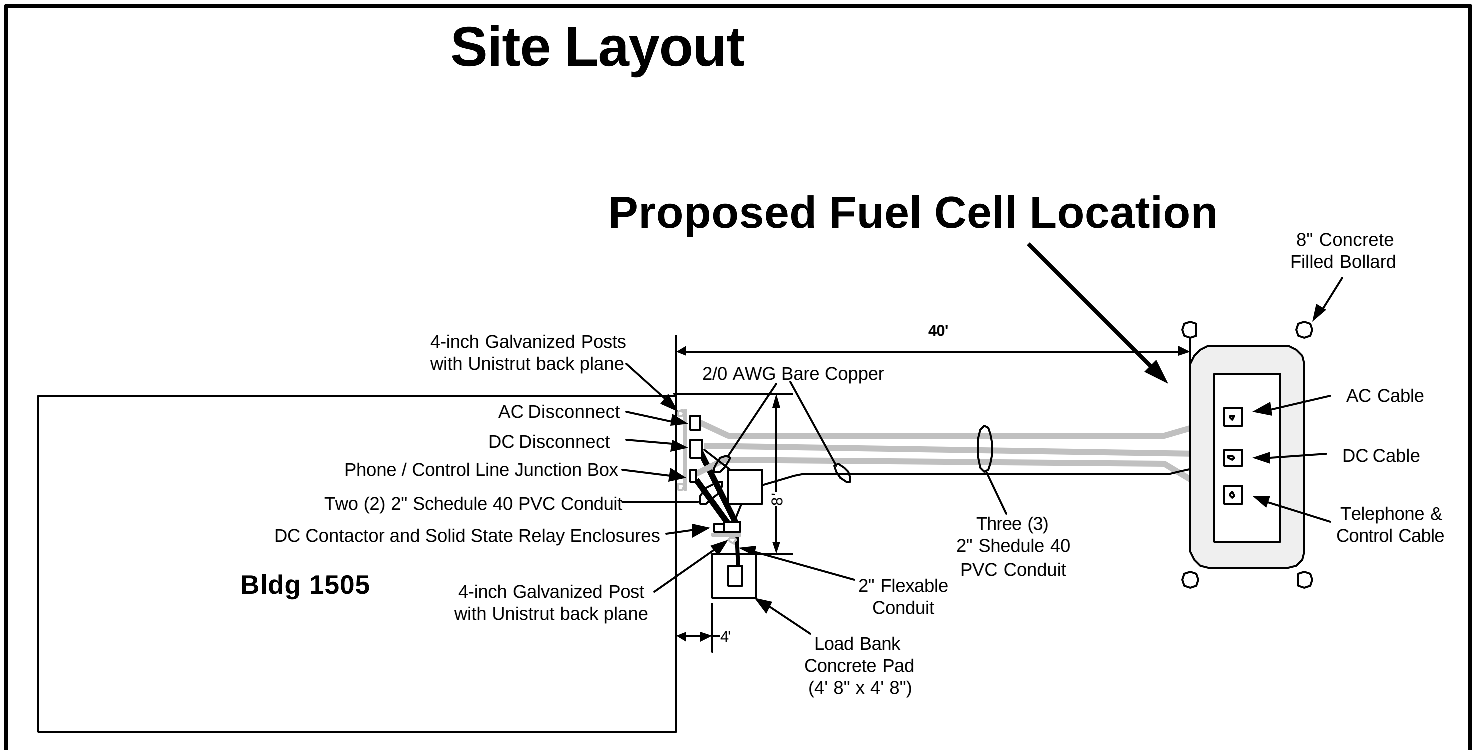

Figure 5

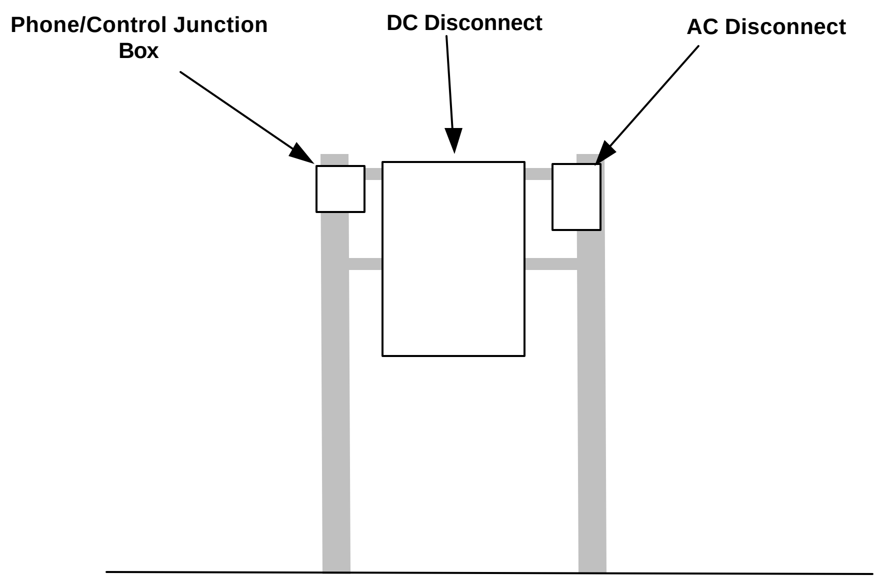

Figure 6

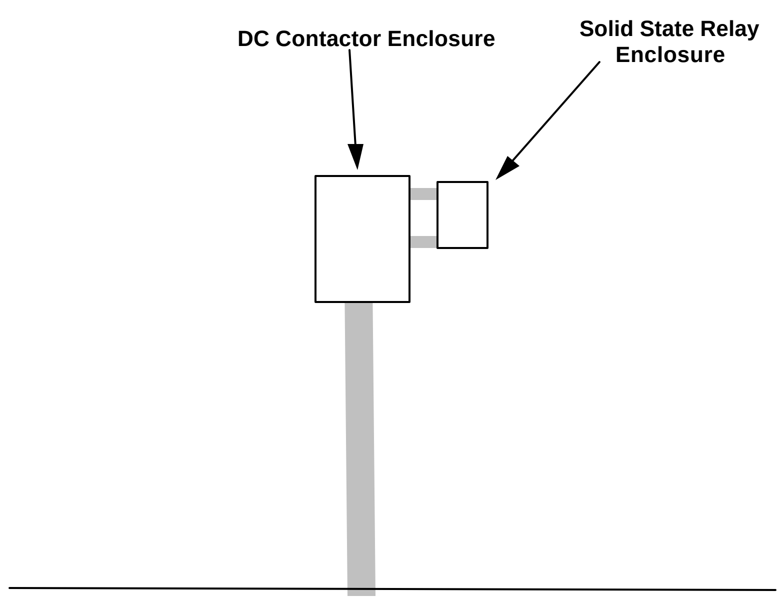

Figure 7

Building Preparation

Figure 8, below, is a top-down view of Bldg. 1505. Junction boxes will be installed for the DC power connection to the RTR site DC buss. A fuse panel will be installed for the DC contactors and control circuits, and a control enclosure will be installed for the automatic connection circuit PLC and relays. Conduits will be installed from the junction boxes installed outside of the building to connection points within the building. A 2-inch conduit will be installed for the DC power cable connection the to the DC buss of the RTR site. A 1-inch conduit will be installed for the connection of AC power to the fuel cell enclosure. A ¾-inch conduit will be installed for the control cables and telephone lines.

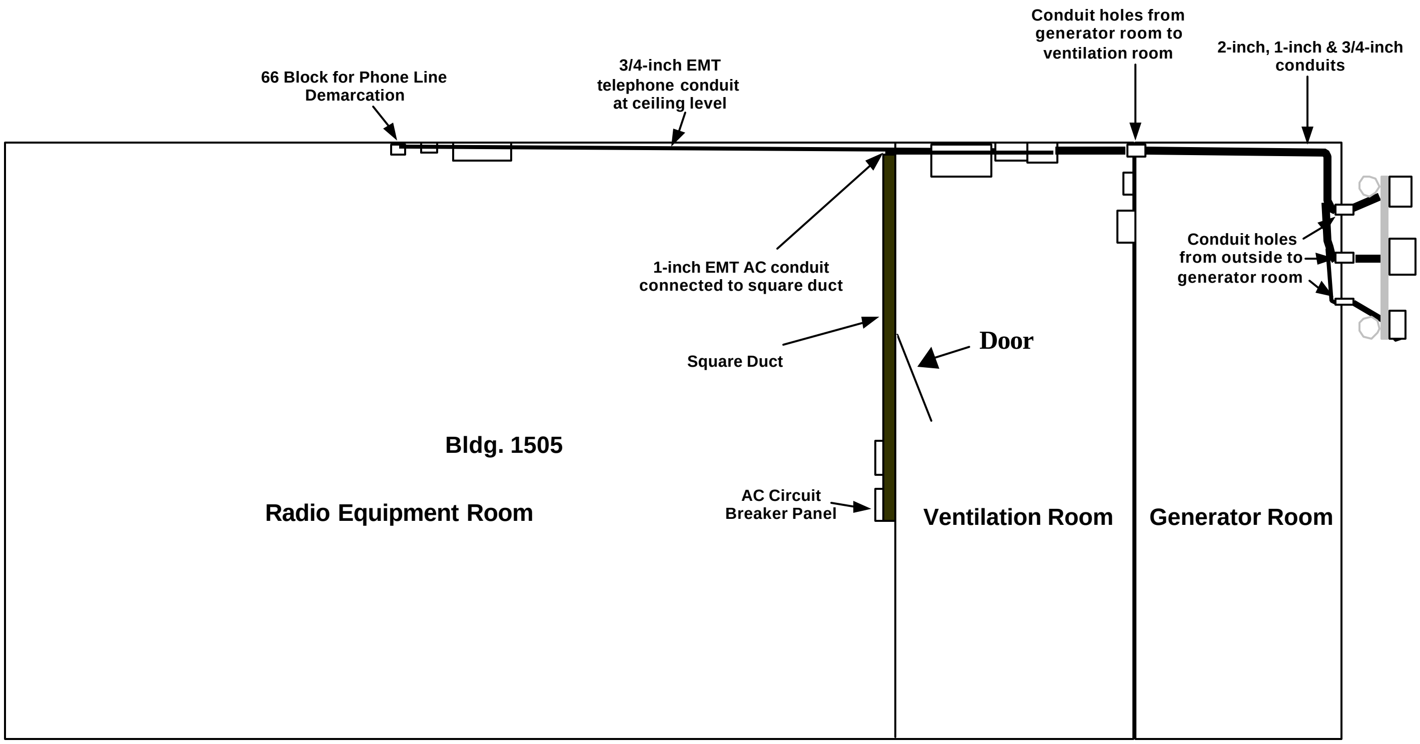

Figure 8

Ventilation Room Preparation

Figure 9 below depicts the North and East walls of the ventilation room in Bldg. 1505. The DC Junction box, DC fuse panel, control enclosure and conduit will be installed as shown. Figure 9 also contains a digital photo of the North wall of the ventilation room.

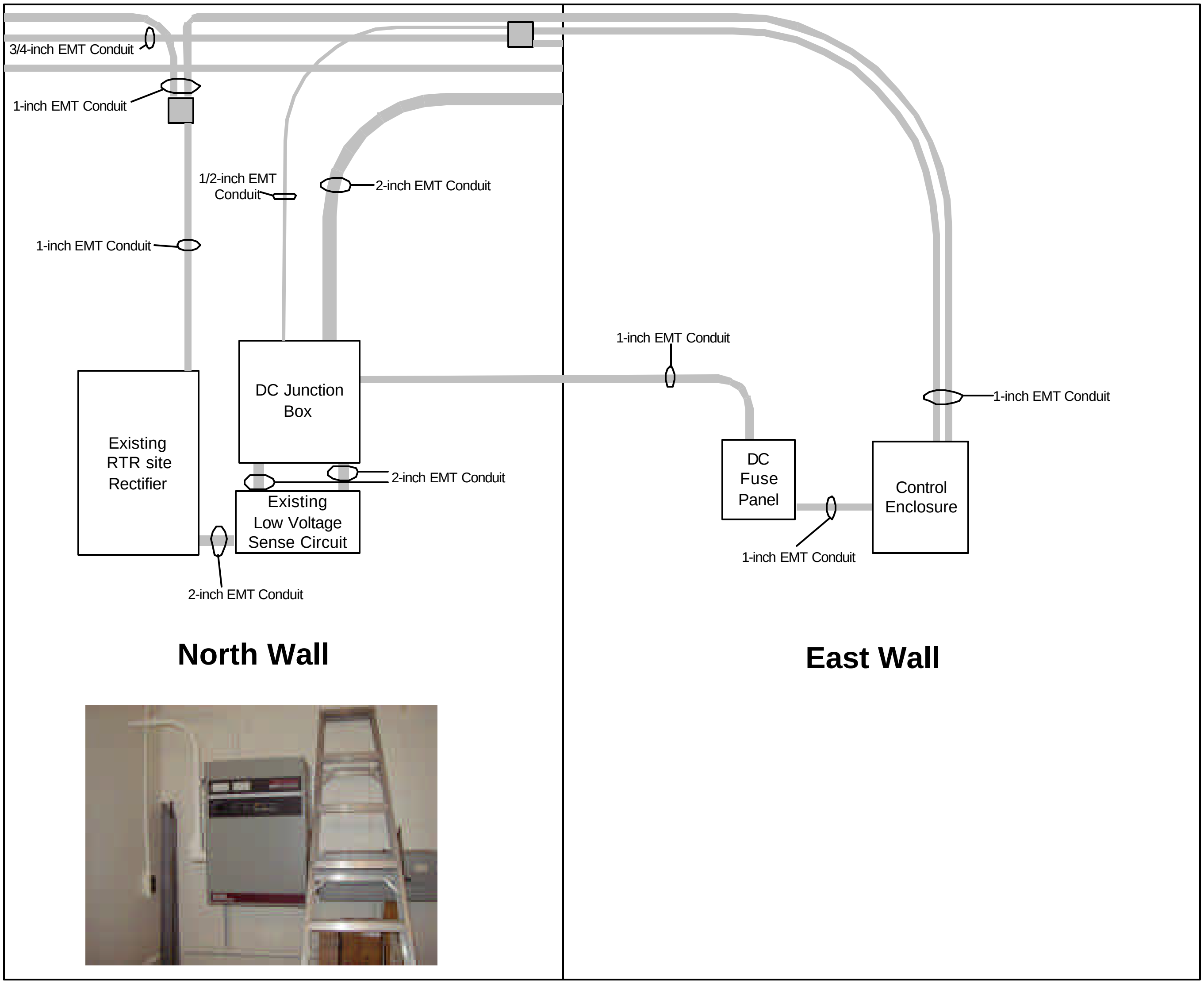

Figure 9

Hydrogen Supply System

Hydrogen Storage and Supply System

The outdoor enclosure is designed with an integrated hydrogen storage and delivery system. The hydrogen is stored in cabinets on the sides of the enclosure. Each cabinet will accommodate three 261 cubic foot bottles of hydrogen, with a total storage capacity of six 261 cubic foot bottles. The hydrogen bottles are secured in place with nylon straps. Each compartment contains a manifold assembly, pressure regulator, manual shutoff valve, and solenoid valve. See Figure 10 below.

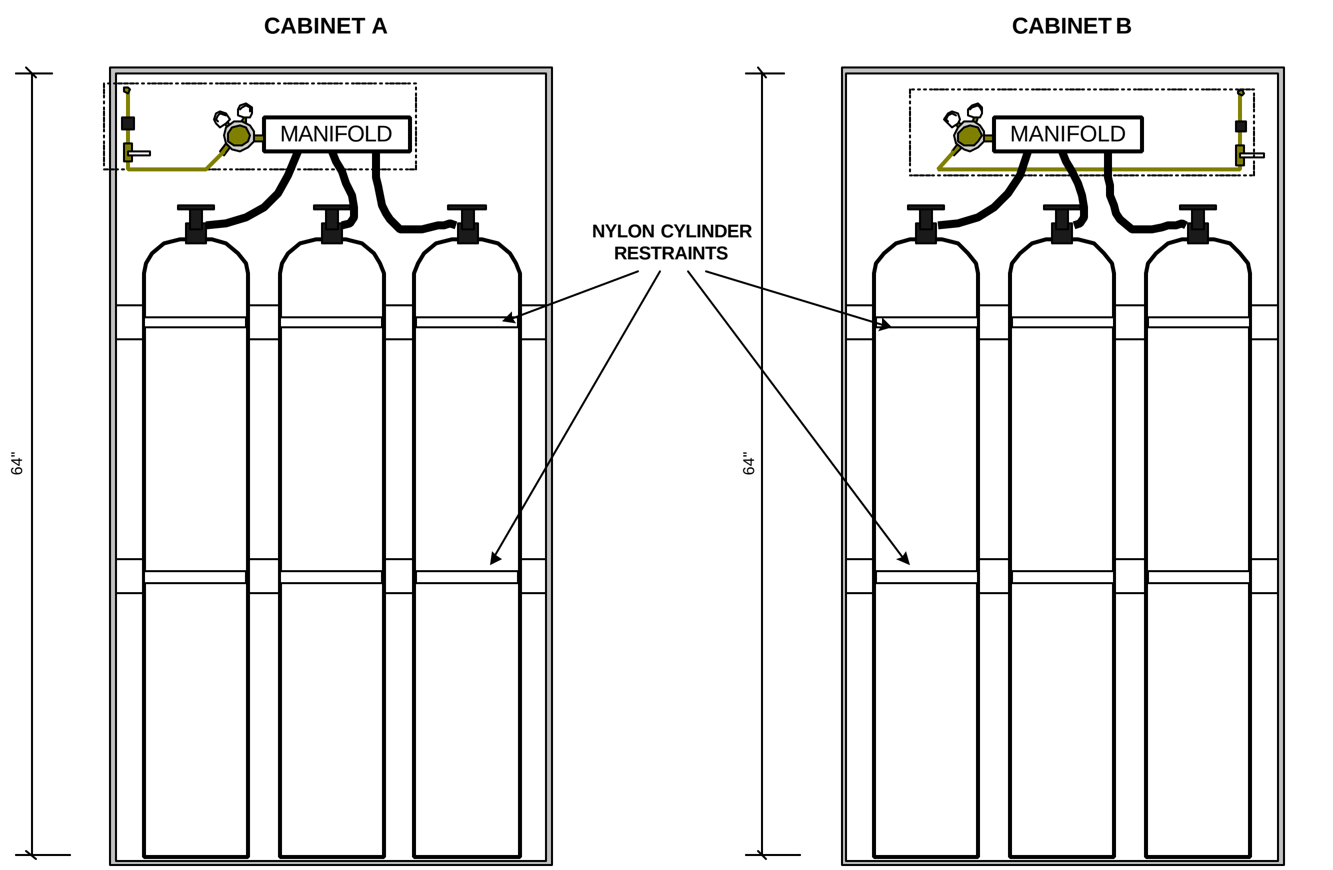

Figure 10

Hydrogen Supply Piping and Safety Circuit

The hydrogen is piped into the fuel cell cabinets of the enclosure using ¼-inch brass tubing. Prior to distribution to the fuel cells, a flow meter is connected in line to capture the flow rate of the hydrogen. Each fuel cell compartment contains a regulator to regulate the pressure to 5 PSI prior to connection to the fuel cells. The hydrogen bleed from each fuel cell compartment is vented out though a vent tube on the roof of each compartment. Brushless DC exhaust fans will evacuate each fuel cell cabinet for one minute prior to system start. Hydrogen sensors will be placed in each fuel cell cabinet. The hydrogen supply solenoids are normally closed and will be interlocked with the normally closed contacts of the sensors. If a leak is detected, the solenoids will be de-energized. The hydrogen sensor alarm must clear before the solenoids can be re-energized. A flow orifice limits the flow of hydrogen to 2 cubic feet per minute. See Figure 11 below.

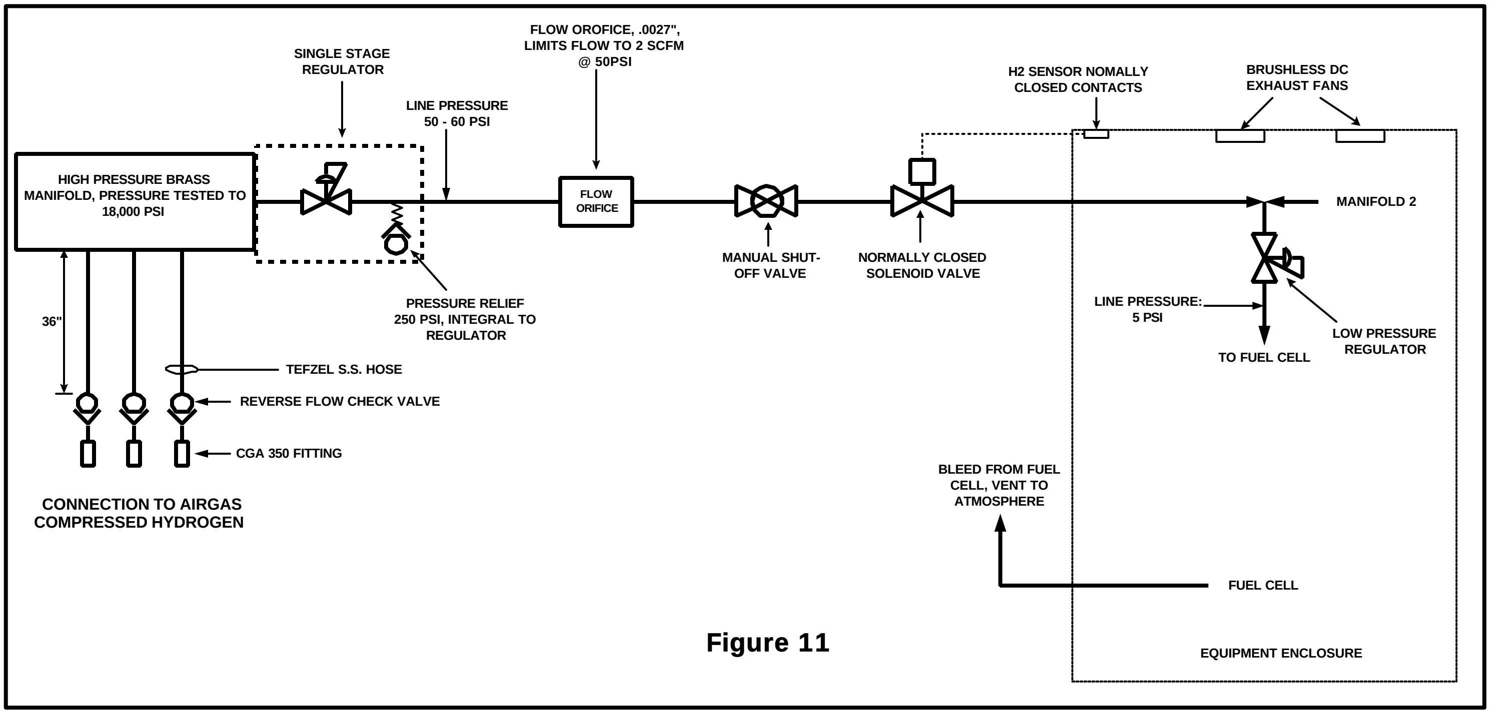

Figure 11

Electrical

Outdoor Enclosure

The fuel cell system will be connected to the internal battery bank through a 150 Amp circuit breaker. The output of the battery bank will be connected to the DC disconnect through a 150 Amp circuit breaker. DC Voltage and current sensors will be placed on each side of the internal battery bank to capture the voltage and current out of the fuel cells and the voltage and current out of the system to the load. See Figure 12 below.

Phase 1 Testing

The DC disconnect will be connected to two contactors that will be controlled by PLC 2 located in the control enclosure in the ventilation room of Bldg. 1505. The contactor connecting the fuel cell system to the load bank will be normally energized. The contactor that will connect the fuel cell system to the FAA battery bank and DC buss will normally be de-energized. PLC 1 in the fuel cell Outdoor Enclosure will control solid state relays that will ramp in the 1 kW resistive load resisters of the load bank. See Figure 12 below.

Phase 2 Testing

During phase 2 of the system test, the normally energized contactor will be de-energized and the normally de-energized contactor will be energized by PLC 2, allowing the fuel cell system to be connected to the FAA DC buss. A blocking diode is used to prevent the FAA DC Buss from back feeding the fuel cell system battery bank. A normally closed relay will be utilized to simulate power loss to the FAA 24 VDC rectifier. During the simulated power outage the relay will be opened removing the AC grid power from the rectifier. See Figure 12 below.

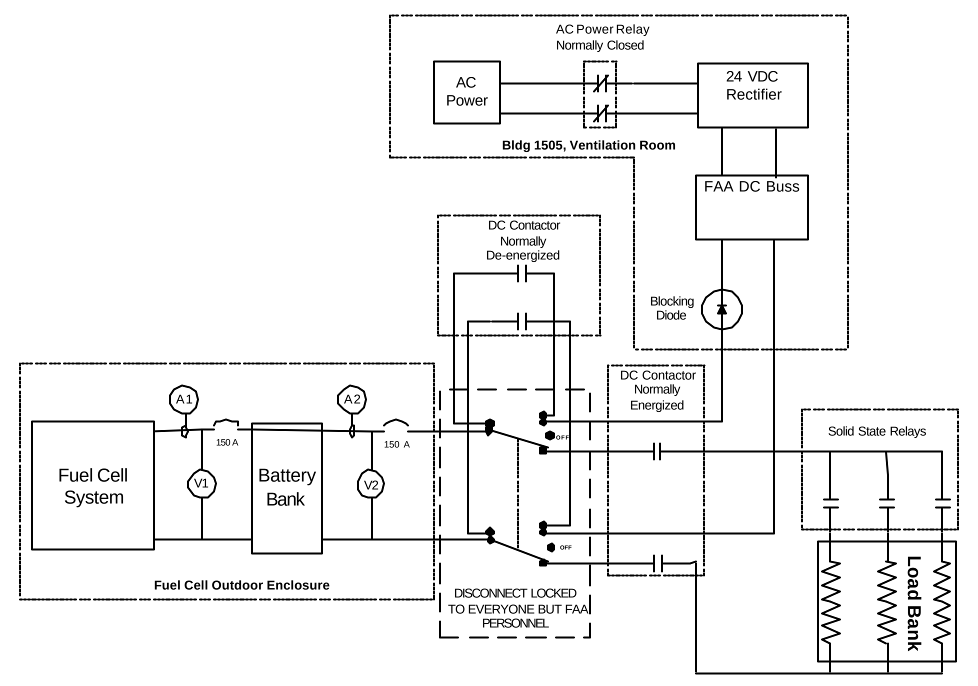

Figure 12

Data Acquisition

The data acquisition system is detailed in Figure 13. A data collection unit will be connected to various sensors. Each fuel cell and the data collection unit will be connected to the data-logging computer though an Ethernet hub. The data-logging computer will log total operating hours of the fuel cells, kilowatt hours produced, fuel consumption, maintenance logs, fuel cell system availability, outages and operating temperature. Additionally, it will log internal and external temperature and humidity. The data from the data-logging computer will be downloaded to a server located at Avista Labs by remote dialup after each scheduled system run. The data-logging computer will also log alarms for the following conditions: AC power loss, H2 sensor alarm, low power output during test run, system voltage below 24 VDC, fuel cell cartridge off-line and fuel cell shutdown. The data-logging computer alarm notification utility will dial pre-programmed telephone numbers to alert Avista Labs of any alarm condition.

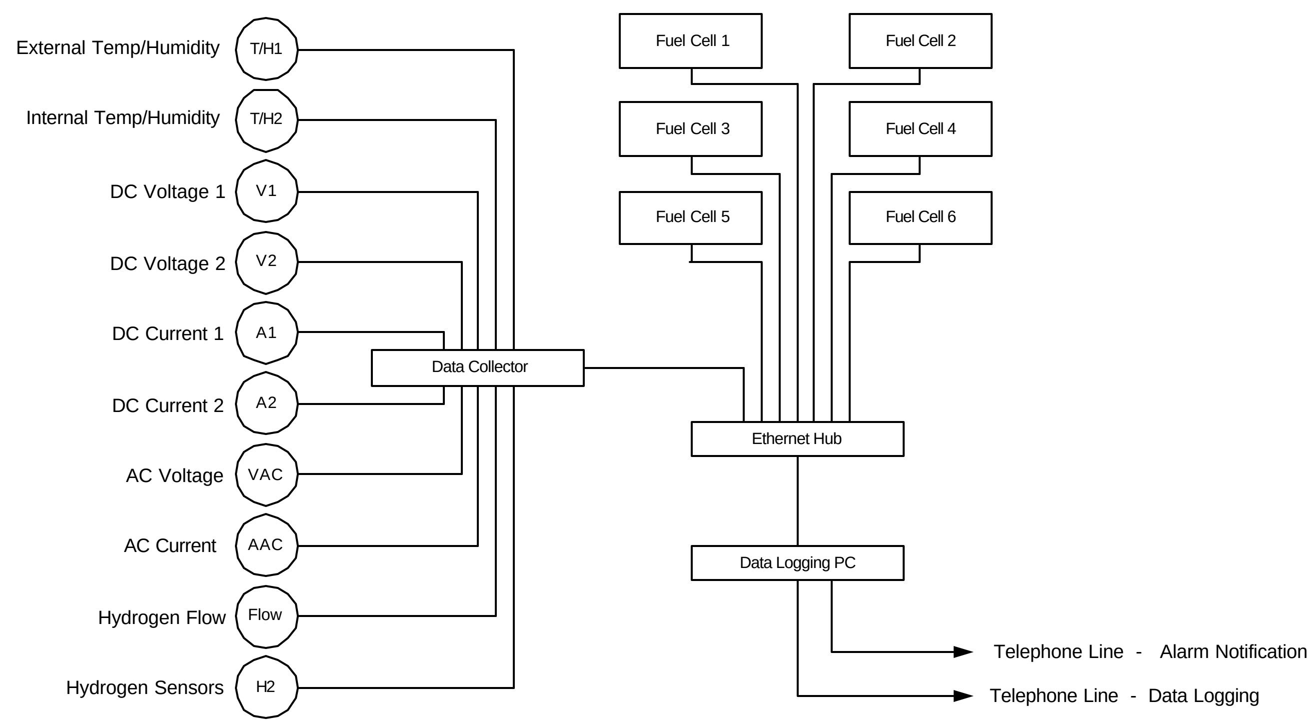

Figure 13

Economic Analysis

Backup power for facilities similar to the FAA RTR site using generators and batteries is estimated to be approximately $2 to $3 per kWh based upon the cost of fuel, maintenance and environmental consideration due hazardous fuel or material. The cost of hazardous fuel or material disposal can actually increase the cost per kWh significantly. The calculated cost of power generated by the Independence 500 fuel cell is $2.55/kWh based upon the current cost of hydrogen. Based upon this comparison, and the advantages of utilizing an environmental friendly source of backup power, the hydrogen powered fuel cell system can be a better economic choice for backup power systems. As hydrogen demand increases and the hydrogen delivery infrastructure expands, the cost of hydrogen is likely to decrease, resulting in a stronger economic advantage for hydrogen powered fuel cells in backup power applications.